62-4-6

REPORT NO. FZM-2671
DATE: 9 August 1962

SUMMARY OF QUALIFICATION TEST DATA HIGH TEMPERATURE PHENOLIC GLASS REINFORCED HONEYCOMB CORE PER FMS-0013.

Published and Distributed Under
Contract No. AF33(657)-7248

GENERAL DYNAMICS | FORT WORTH

Department 6
FWP 1999—9-54

C O N V A I R
A DIVISION OF GENERAL DYNAMICS CORPORATION
(FORT WORTH)

MODEL

REPORT FZM-2671
DATE 9 August, 1962

TITLE

SUMMARY OF QUALIFICATION TEST DATA HIGH TEMPERATURE PHENOLIC GLASS RE-INFORCED HONEYCOMB CORE PER FMS-0013

SUBMITTED UNDER

Contract No. AF 33(657)-7248

Tests conducted between 3/10/55 and 6/6/61

PREPARED BY: S F Monroe
S. F. Monroe
Senior Design Engineer

GROUP: Engineering Materials and Processes

REFERENCE: _____

CHECKED BY: _____

APPROVED BY: D C Wilson
D. C. Wilson
Design Group Engineer

NO. OF PAGES _____

NO. OF DIAGRAMS _____

REVISIONS

NO.	DATE	BY	CHANGE	PAGES AFFECTED

- FOREWORD -

This report is a summary of the qualification test data of glass reinforced high temperature phenolic honeycomb core to the requirements of FMS-0013.

The test materials were supplied by Hexcel Products and Honeycomb Products.

The summary of the test data from the following Engineering Test Laboratory reports are included:

FTDM 2108	FTDM 1971	55-001
2105	1596	
2146	1693	
2397	1421	

Report No. FTDM 2312 is included as typical of the above reports.

C O N V A I R
FORT WORTH

Department 6
FWP 2376 - 2 - 53

TEST DATA MEMORANDUM

FTDM NO. 2312
MODEL B-58
TEST NO. F-8772

TEST: MATERIAL - Hexcel Products Inc. HRL Glass Fabric Reinforced Plastic Honeycomb Core - Qualification to FMS-0013 (B) Types II, III and VI.

OBJECT: To determine if Hexcel Products Inc.'s HRL series glass fabric reinforced plastic honeycomb core, submitted as Types II, III and VI of Convair Specification FMS-0013 (B), conforms to FMS-0013 (B) requirements for Types II, III and VI core.

TEST SPECIMENS: HRL glass fabric reinforced honeycomb core, Types II, III and VI of FMS-0013 (B) -0.625" thick slices. Hexcel log designations: B2-1900 II (Type II), B2-1482 (Type III) and B2-1513 II (Type VI). Hexcel Products Inc. Berkeley, Calif.

PROCEDURE: An outline of the test procedure according to FMS-0013 (B) is shown in Table I. The fabrication and bonding procedure for sandwich panels is shown in Table II.

RESULTS: Results are shown in Tables III and V through X with a summary in Table IV.

DISCUSSION: HRL series glass fabric reinforced honeycomb core (Types I, IV, V and VII of FMS-0013 B), submitted by Hexcel Products Inc., has been qualified to FMS-0013 (B) (Convair Report FTDM-2146). Therefore, the qualification of the remaining FMS-0013(B) Types II, III and VI of Hexcel HRL core will make available all FMS-0013 (B) types of glass fabric reinforced honeycomb core for use on the B-58 aircraft.

The cell size and apparent density of the core tested are shown in Table III, and are within the limits of FMS-0013(B) for Types II, III and VI core. Each slice of Type III core received for qualification contained a small area of excess resin accumulation, as shown by the arrow in Figure 1.

The bare core flatwise compressive strength at 80° and 260°F of each type core exceeded the minimum FMS-0013(B) requirements, as shown in the summary Table IV and in Tables V and VI. Tables V and VI also include the compressive modulus (not required for qualification) of each specimen.

The shear strength in the W (transverse) and L (longitudinal) ribbon directions, and the shear modulus of rigidity in the W and L ribbon directions at both test temperatures of 80° and 260°F, of each type core exceeded the minimum FMS-0013(B) requirements, as shown in the summary Table IV and in Tables VII through X. Tables VII through X also include the type failure of each specimen.

The shear strength and modulus of rigidity requirements for Types III and VI core shown in FMS-0013(B) Table B are incorrect. For the purpose of qualifying Types III and VI core in this test, the W and L ribbon direction requirements were interchanged at the request of the test originator. This change will be incorporated into FMS-0013 revision C at a later date.

CONCLUSIONS: Hexcel Products Inc.'s HRL series glass fabric reinforced plastic honeycomb core, submitted as Types II, III and VI of Convair Specification FMS-0013(B), conforms to all FMS-0013(B) requirements for types II, III and VI core.

Tests described above were conducted between 7-28-59 and 8-14-59.

WITNESS: B. Grimes

*See Supplementary Sheets.

DATE: 26 August 1959

BY R. L. Miller

CHECKED B. Grimes

APPROVED H. H. Swan
A. C. Wilson

TABLE I

TEST PROCEDURE FOR HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - - TYPES II, III AND VI

I. Slices of each type core were machine sanded to a finished thickness of 0.504 ± .003".

II. The cell size and apparent density of each slice of core tested were determined by measurement.

III. Bare core flatwise compression test specimens were prepared and tested at 80° ± 5°F and at 260° ± 5°F after 30 minutes at 260°F, according to FMS-0013(B). Five specimens of each type core were tested at each temperature. The test apparatus, as employed at 80°F, is shown in Figures 1 and 2 of Convair Report FTDM-1971. For testing at 260°F, the apparatus was enclosed in a controlled temperature chamber. Load versus deflection curves were made during the loading of each specimen by means of a high magnification extensometer. Actual load rates used were as follows:

Type Core	Load Rate (Lbs/Min.)
II	650
III	2000
VI	1500

The compressive strength of each specimen was calculated according to FMS-0013(B). The Compressive modulus of each specimen was calculated with the following formula:

$$G = \frac{S \times T}{L \times W}$$

Where G = Compressive modulus (psi)
S = Slope of load vs. deflection curve (Lb/in)
T = Specimen thickness (in)
L = Specimen length (in)
W = Specimen width (in)

IV. Simple beam flexure specimens were prepared according to FMS-0013(B) from sandwich panels bonded as outlined in Table II. Six specimens of each type core in the L (longitudinal) ribbon direction, and six in the W (transverse) ribbon were prepared. The specimens were tested at 80 ± 5°F and at 260 ± 5°F after 30 minutes at 260°F, according to FMS-0013(B). The test apparatus, as employed at 80°F., is shown in Figures 3 and 4 of Convair Report FTDM-1971. For testing at 260°F, the apparatus was enclosed in a controlled temperature chamber.

TABLE I (Continued)

The flatwise flexural shear strength and the flatwise shear modulus of rigidity of each specimen were calculated according to FMS-0013(B) using the following formulas:

Shear Strength (LB/IN) = $\frac{P}{W}$; where P = Ultimate load (LBS)

and W = Specimen Width (IN)

Modulus of rigidity (PSI) = $\frac{S\ L\ Tc}{2TW\ (T \not{/} Tc)(1 - \frac{SL^3}{48D})}$;

where $D = \frac{W\ T_f^2\ (T \not{/} Tc)^2\ E_f}{4F\ (T - Tc)}$ = Computed stiffness

of specimen without considering the deflection due to shear (IN^4),

S = Initial straight line slope of load vs. deflection curve (LB/IN),

L = Length of span (IN) = 6 IN,

Tc = core thickness (IN),

T = specimen thickness (IN),

W = specimen width (IN),

T_f = thickness of one facing (IN) = .040 IN,

E_f = Modulus of elasticity of facing material (2024T-86 Alclad Aluminum)

= 10.6×10^6 at 80°F

= 9.6×10^6 at 260°F,

F = $(1 - U_f^2)$, where U_f is Poisson's ratio of facing material

= .33.

TABLE II

FABRICATION AND BONDING PROCEDURE FOR SANDWICH PANELS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - TYPES II, III AND VI

I. Facings: 8.0" x 23.0" x 0.040" 2024T-86 Alclad Aluminum.

II. Cleaning of Metal Facings

A. Remove foreign substances with methyl ethyl ketone.

B. Vapor degrease in stabilized trichloroethylene for 10 minutes.

C. Immerse for 11-13 minutes in an acid solution of the following composition maintained at 160 ± 10°F.:

4 parts by weight sodium dichromate

10 parts by weight Conc. sulphuric acid (66° Bé)

30 parts by weight water

D. Rinse with tap water. Spray rinse with distilled water.

E. Dry in an oven at 160 ± 10°F for at least 20 minutes.

III. Cleaning of Core

A. Spray rinse with distilled water to remove dust and other foreign substances.

B. Dry in an oven at 160 ± 10°F for 20 minutes.

C. Vapor degrease in stabilized trichloroethylene for 10 minutes.

D. Air dry at least 20 minutes.

IV. Fabrication of Panels

A. Handle cleaned facings and core with clean cotton gloves.

B. Apply one thickness of FMS-0015(D) dry film adhesive (Aerobond 422, Lot 5150) to each facing.

C. Assemble facings with core to form a 8.0" x 23.0" standard sandwich panel.

TABLE II (Continued)

V. Bonding Conditions

A. Cover entire bonding surface with 1/16" thickness of curable rubber.

B. Place whole assembly in an electrically heated bonding press with platens at room temperature.

C. Apply bonding pressure as follows:

Type Core	Bonding Pressure
II	75 psi
III	150 psi
VI	150 psi

D. Raise glueline temperature to 350°F. Maintain at 350 ± 10°F for 120 ± 10 minutes.

E. Cool glueline temperature to less than 180°F. Release pressure. Remove panel from press.

TABLE III

PHYSICAL PROPERTIES OF HEXCEL HRL GLASS FABRIC
REINFORCED HONEYCOMB CORE- TYPES II, III AND VI

TYPE-SLICE NO.	CELL SIZE (IN)	WIDTH (IN)	LENGTH (IN)	THICK-NESS (IN)	VOLUME (FT^3)	WEIGHT (LBS)	APPARENT DENSITY (LB/FT^3)
II-1	1/4	8.00	19.93	.504	.0465	.236	4.97
II-2	1/4	8.04	21.20	.504	.0497	.242	4.87
FMS-0013(B) REQUIREMENT PER SLICE:							4.4-5.2
III-1	1/8x3/8	8.03	20.11	.505	.0472	.446	9.45
III-2	1/8x3/8	8.05	20.02	.505	.0471	.467	9.91
FMS-0013(B) REQUIREMENT PER SLICE:							8.0-9.8
VI-1	1/8x3/8	8.00	19.91	.506	.0469	.369	7.88
VI-2	1/8x3/8	8.04	20.02	.505	.0470	.346	7.36
FMS-0013(B) REQUIREMENT PER SLICE:							6.25-8.0

TABLE IV

SUMMARY OF QUALIFICATION TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - TYPES II, III AND VI

I. Bare Core Flatwise Compressive Strength:

FMS-0013(B) TYPE CORE	AVE. COMPRESSIVE STRENGTH (PSI)		FMS-0013(B) MIN. AVE. REQUIREMENT (PSI)	
	80°F	260°F	80°F	260°F
II	786	598	500	400
III	1845	1350	600	550
VI	1400	1170	480	440

II. Bare Core Flatwise Compressive Modulus:

FMS-0013(B) TYPE CORE	AVE. COMPRESSIVE MODULUS (PSI)		FMS-0013(B) REQUIREMENT
	80°F	260°F	
II	51,800	47,900	None
III	109,000	73,000	"
VI	84,200	68,900	"

III. Flexural Shear Strength:

FMS-0013(B) TYPE CORE	RIBBON DIRECTION	AVE. SHEAR STRENGTH (LB/IN)WIDTH		MIN. AVE. FMS0013(B) REQUIREMENT (LB/IN)WIDTH	
		80°F	260°F	80°F	260°F
II	W	272	233	225	180
	L	489	413	400	350
III	W	697	571	475	400
	L	422	361	320	260
VI	W	582	506	350	300
	L	381	338	240	200

TABLE IV (Continued)

IV. Flexural Shear Modulus of Rigidity:

FMS-0013(B) TYPE CORE	RIBBON DIRECTION	AVE. MODULUS OF RIGIDITY (PSI)		MIN. AVE. FMS-0013(B) REQUIREMENT (PSI)	
		80°F	260°F	80°F	260°F
II	W	16,200	13,300	8,000	6,000
	L	31,500	25,500	19,000	16,000
III	W	61,600	47,800	23,000	20,000
	L	24,500	19,100	12,000	10,000
VI	W	47,600	35,600	18,000	15,000
	L	18,900	15,000	9,000	7,500

TABLE V

BARE CORE FLATWISE COMPRESSION TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE- TYPES II, III AND VI
TEST TEMPERATURE: 80°F

TYPE-SPECIMEN NO.	SPECIMEN DIMENSIONS LENGTH (IN)	WIDTH (IN)	THICK. (IN)	LOAD TO FAILURE (LBS)	COMPRESSIVE STRENGTH (PSI)	SLOPE* (LB/IN)	COMPRESSIVE MODULUS** (PSI)
II-1	2.02	2.03	.503	2935	715	427,000	52,300
II-2	1.99	2.01	.505	3540	885	421,000	53,000
II-3	2.01	2.01	.503	3140	778	431,000	53,800
II-4	2.02	2.00	.506	3025	750	390,000	48,800
II-5	2.02	2.03	.505	3295	803	415,000	51,200
AVERAGE					786		51,800
MIN. AVE. FMS-0013(B) REQUIREMENT					500		NONE
III-1	2.00	2.01	.504	7420	1850	837,000	104,900
III-2	1.98	2.04	.506	8660	2140	993,000	124,300
III-3	1.97	2.07	.504	7760	1900	885,000	109,000
III-4	2.06	2.08	.504	6440	1500	842,000	98,900
III-5	2.00	2.09	.504	7700	1840	893,000	107,700
AVERAGE					1845		109,000
MIN. AVE. FMS-0013(B) REQUIREMENT					600		NONE
VI-1	2.03	2.08	.502	4880	1160	625,000	74,300
VI-2	2.00	2.04	.503	5175	1270	625,000	77,000
VI-3	2.05	2.05	.503	5480	1300	625,000	74,800
VI-4	2.03	2.07	.497	6550	1560	807,000	95,500
VI-5	2.04	2.11	.496	7300	1700	863,000	99,500
AVERAGE					1400		84,200
MIN. AVE. FMS-0013(B) REQUIREMENT					480		NONE

*SLOPE: slope of load vs. deflection curve.
**COMPRESSIVE MODULUS: $\text{slope} \times \frac{\text{thickness}}{\text{length} \times \text{width}}$

TABLE VI

BARE CORE FLATWISE COMPRESSION TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - TYPES II, III AND VI
TEST TEMPERATURE: 260°F

TYPE-SPECIMEN NO.	SPECIMEN DIMENSIONS LENGTH (IN)	WIDTH (IN)	THICK. (IN)	LOAD TO FAILURE (LBS)	COMPRESSIVE STRENGTH (PSI)	SLOPE* (LB/ IN)	COMPRESSIVE MODULUS** (PSI)
II-6	2.01	2.00	.505	2630	654	471,000	59,200
II-7	2.00	2.05	.503	2475	604	313,000	38,400
II-8	2.01	2.04	.503	2900	707	395,000	48,400
II-9	1.99	2.01	.496	1850	462	No Curve	---
II-10	2.02	2.02	.505	2300	564	368,000	45,500
AVERAGE					598		47,900
MIN. AVE. FMS-0013(B) REQUIREMENT					400		NONE
III-6	2.02	2.08	.504	6050	1440	500,000	60,000
III-7	2.09	2.03	.506	5325	1250	638,000	76,100
III-8	2.01	2.02	.504	5550	1365	556,000	69,000
III-9	1.96	2.09	.505	5080	1240	544,000	67,000
III-10	1.99	2.01	.504	5840	1460	736,000	92,800
AVERAGE					1350		73,000
MIN. AVE. FMS-0013(B) REQUIREMENT					550		NONE
VI-6	2.03	2.09	.506	5400	1270	610,000	72,900
VI-7	1.99	2.04	.504	5375	1320	641,000	79,500
VI-8	1.96	1,98	.506	5020	1290	610,000	79,600
VI-9	2.02	2.04	.505	4245	1010	481,000	57,800
VI-10	1.99	2.00	.506	3925	990	432,000	55,000
AVERAGE					1170		68,900
MIN. AVE. FMS-0013(B) REQUIREMENT					440		NONE

*SLOPE: slope of load vs. deflection curve.
**COMPRESSIVE MODULUS: slope X $\frac{\text{thickness}}{\text{length x width}}$

UTILITY REPORT SHEET

TABLE VII

SIMPLE BEAM FLEXURE TEST RESULTS OF HEXCEL HRL GLASS FABRIC
REINFORCED HONEYCOMB CORE - TYPES II AND III
TEST TEMPERATURE: 80°F

TYPE - SPECIMEN NO.	RIBBON DIREC- TION	SPECIMEN THICKNESS (IN)	CORE THICKNESS (IN)	SPECIMEN WIDTH (IN)	LOAD TO FAILURE (LBS)	SHEAR STRENGTH (LB/IN. WIDTH)	SLOPE* (LB/IN)	MODULUS OF RIGIDITY (PSI)	TYPE FAIL -URE**
II-1	W	.596	.504	2.98	830	278	13,300	16,900	HS
II-3	W	.594	.504	2.99	819	274	13,100	16,200	HS
II-5	W	.595	.504	2.98	784	263	12,600	15,500	HS
AVERAGE						272		16,200	
MIN. AVE.	FMS-0013(B) REQUIREMENT					225		8,000	
II-7	L	.595	.504	2.98	1460	490	20,100	33,800	HS
II-9	L	.593	.504	2.98	1435	481	19,200	30,500	HS
II-11	L	.594	.504	2.97	1470	495	19,000	30,200	HS
AVERAGE						489		31,500	
MIN. AVE.	FMS-0013(B) REQUIREMENT					400		19,000	
III-1	W	.594	.505	2.98	2100	705	27,700	69,600	BOND
III-3	W	.593	.505	2.97	2050	686	25,600	54,500	BOND
III-5	W	.593	.505	2.96	2070	699	26,300	60,700	BOND
AVERAGE						697		61,600	
MIN. AVE.	FMS-0013(B) REQUIREMENT ***					475		23,000	
III-7	L	.595	.505	2.98	1280	430	18,300	27,900	DS
III-9	L	.593	.505	2.97	1230	414	16,500	23,300	DS
III-11	L	.593	.505	2.97	1255	422	16,000	22,200	BOND
AVERAGE						422		24,500	
MIN. AVE.	FMS-0013(B) REQUIREMENT ***					320		12,000	

*SLOPE: slope of load vs. deflection curve.

**TYPE FAILURE: HS- horizontal shear, DS- diagonal shear (DS type failures are described in Convair Report FGT-1911), BOND- core to facing bond failure.

***The L and W ribbon direction requirements for both shear strength and modulus of rigidity of type III core shown in FMS-0013(B) were interchanged. This change will be incorporated into FMS-0013 at a later date.

Department 6
FWP 1072-8-54

TABLE VIII

SIMPLE BEAM FLEXURE TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE- TYPE VI

TEST TEMPERATURE: 80°F

TYPE - SPECIMEN NO.	RIBBON DIRECTION	SPECIMEN THICKNESS (IN)	CORE THICKNESS (IN)	SPECIMEN WIDTH (IN)	LOAD TO FAILURE (LBS)	SHEAR STRENGTH (LB/IN. WIDTH)	SLOPE* (LB/IN)	MODULUS OF RIGIDITY (PSI)	TYPE FAILURE**
VI-1	W	.596	.505	3.00	1650	550	23,300	45,100	HS
VI-3	W	.597	.505	3.00	1880	627	24,800	52,900	HS
VI-5	W	.595	.505	2.98	1700	570	23,100	44,800	HS
AVERAGE						582		47,600	
MIN. AVE. FMS-0013(B) REQUIREMENT***						350		18,000	
VI-7	L	.594	.506	2.98	1135	380	14,300	18,500	HS
VI-9	L	.598	.506	2.98	1140	384	14,800	19,700	HS
VI-11	L	.597	.506	2.98	1130	379	14,100	18,400	HS
AVERAGE						381		18,900	
MIN. AVE. FMS-0013(B) REQUIREMENT***						240		9,000	

*SLOPE: slope of load vs. deflection curve.
**TYPE FAILURE: HS- horizontal shear .
***The W and L ribbon direction requirements for both shear strength and modulus of rigidity of type VI core shown in FMS-0013(B) were interchanged. This change will be incorporated into FMS-0013 at a later date.

TABLE IX

SIMPLE BEAM FLEXURE TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - TYPES II AND III
TEST TEMPERATURE: 260°F

TYPE-SPECIMEN NO.	RIBBON DIRECTION	SPECIMEN THICKNESS (IN)	CORE THICKNESS (IN)	SPECIMEN WIDTH (IN)	LOAD TO FAILURE (LBS)	SHEAR STRENGTH (LB/IN.WIDTH)	SLOPE* (LB/IN)	MODULUS OF RIGIDITY (PSI)	TYPE FAILURE**
II-2	W	.594	.504	2.99	718	240	11,500	14,100	HS
II-4	W	.593	.504	2.98	668	224	11,100	13,500	HS
II-6	W	.596	.504	2.99	704	235	10,300	12,200	HS
AVERAGED						233		13,300	
MIN. AVE. FMS-0013(B) REQUIREMENT						180		6,000	
II-8	L	.594	.504	2.97	1270	427	16,000	24,100	HS
II-10	L	.593	.504	2.98	1230	413	16,700	25,500	HS
II-12	L	.594	.504	2.98	1188	398	17,100	26,900	HS
AVERAGED						413		25,500	
MIN. AVE. FMS-0013(B) REQUIREMENT						350		16,000	
III-2	W	.593	.505	2.98	1720	577	22,900	48,500	DS
III-4	W	.592	.505	2.98	1670	560	22,500	46,000	DS
III-6	W	.593	.505	2.97	1710	576	22,900	48,900	DS
AVERAGE						571		47,800	
MIN. AVE. FMS-0013(B) REQUIREMENT***						400		20,000	
III-8	L	.594	.505	2.98	1146	385	14,100	19,200	DS
III-10	L	.593	.505	2.97	1006	338	14,000	19,000	BOND
III-12	L	.595	.505	2.97	1070	360	14,000	19,200	DS
AVERAGE						361		19,100	
MIN. AVE FMS-0013(B) REQUIREMENT***						260		10,000	

*SLOPE: slope of load vs. deflection curve.
**TYPE FAILURE: HS- horizontal shear, DS- diagonal shear(DS type failures are described in Convair Report FGT-1911), BOND- core to facing bond failure.
***The W and L ribbon direction requirements for both shear strength and modulus of rigidity were interchanged. This change will be incorporated into FMS-0013 at a later date.

UTILITY REPORT SHEET

TABLE X

SIMPLE BEAM FLEXURE TEST RESULTS OF HEXCEL HRL GLASS FABRIC REINFORCED HONEYCOMB CORE - TYPE VI

TEST TEMPERATURE: 260°F

TYPE-SPECIMEN NO.	RIBBON DIRECTION	SPECIMEN THICKNESS (IN)	CORE THICKNESS (IN)	SPECIMEN WIDTH (IN)	LOAD TO FAILURE (LBS)	SHEAR STRENGTH (LB/IN. WIDTH)	SLOPE* (LB/IN)	MODULUS OF RIGIDITY (PSI)	TYPE FAILURE**
VI-2	W	.595	.505	2.99	1525	510	20,000	36,000	DS
VI-4	W	.596	.505	2.98	1490	500	19,800	35,500	DS
VI-6	W	.593	.505	2.99	1520	508	20,000	35,200	DS
AVERAGE						506		35,600	
MIN. AVE. FMS-0013(B) REQUIREMENT***						300		15,000	
VI-8	L	.596	.506	2.99	1026	343	12,300	15,500	BOND
VI-10	L	.598	.506	2.98	1028	345	11,800	14,800	DS
VI-12	L	.595	.506	3.00	982	327	11,900	14,800	DS
AVERAGE						338		15,000	
MIN. AVE. FMS-0013(B) REQUIREMENT***						200		7,500	

*SLOPE: slope of load vs. deflection curve.
**TYPE FAILURE: DS- diagonal shear (DS type failures are described in Convair Report FGT-1911), BOND- core to facing bond failure.
***The W and L ribbon direction requirements for both shear strength and modulus of rigidity of type VI core were interchanged. This change will be incorporated into FMS-0013 at a later date.

Introduction

The qualification and procurement requirements for glass fabric reinforced plastic honeycomb core used in the fabrication of sandwich panels are given in FMS0013(c).

FTDM2312 is a typical qualification test report of glass fabric reinforced plastic honeycomb core.

The pertinent sections of FMS0031(c) which are not included in FTDM2312 are given in following sections I to IV.

Section V contains the summary data of other types of core tested for qualification to FMS0013.

Section I Identification of Glass Reinforced Honeycomb Core

TYPE: The core material shall be identified by the following types:

Type I	3/16 inch hexagonal cell size; 9.0 lb/cu.ft., nominal density.
Type II	1/4 inch hexagonal cell size; 4.75 lb/cu.ft., nominal density.
Type III	1/8 inch by 3/8 inch rectangular cell size; 9.0 lb/cu.ft., nominal density.
Type IV	3/16 inch hexagonal cell size; 5.5 lb/cu.ft., nominal density.
Type V	3/16 inch hexagonal cell size; 7.0 lb/cu.ft., nominal density.
Type VI	1/8 inch by 3/8 inch rectangular cell size; 7.0 lb/cu.ft., nominal density.
Type VII	3/16 inch hexagonal cell size; 10.0 lb/cu.ft., nominal density.
Type VIII	1/8 inch by 3/8 inch rectangular cell size; 4.5 lb/cu.ft., nominal density.
Type IX	3/16 inch by 9/16 inch rectangular cell size; 3.1 lb/cu.ft.

Section II Miscellaneous Test Panel Fabrication Procedures

1. Test Panel Face Thickness

CORE TYPE	FACE THICKNESS (in) RT and 260°F	
	W	L
I	0.025	0.040
II	0.016	0.032
III	0.050	0.020
IV	0.012	0.032
V	0.020	0.040
VI	0.040	0.020
VII	0.025	0.040
VIII	0.032	0.012
IX	0.016	0.010

2. Bonding Pressure

TYPE OF CORE	BONDING PRESSURE PSI
I	150
II	50
III	150
IV	150
V	150
VI	150
VII	150
VIII	50
IX	50

3. Cure Cycle

a. Apply the applicable pressure as shown in table above and raise the temperature of the glue lines from room temperature to 235°F ± 15°F at a rate not to exceed 50°F per minute.

b. Maintain the temperature at the glue lines at 325°F ± 15°F for 30 ± 5 minutes.

c. Raise the temperature of the glue lines to 350°F ± 10°F at a rate not to exceed 10°F per minute.

d. Maintain the temperature of the glue lines at 350° ± 10°F for 120 ± 10 minutes.

e. Cool the temperature of the glue lines to less than 180°F before releasing pressure.

Section III Testing Procedures

A. Bare Flatwise Compressive Strength and Modulus of Elasticity:

The bare flatwise compressive strength and modulus of elasticity of the core material are to be determined on bare unsupported specimens of three inch by three inch cross-section by 0.500 ± 0.003 inch thickness, "T" direction. The three inch by three inch flat loading faces are to be sanded parallel, perpendicular to the cell direction, within 0.003 inch.

The compression test fixture shall be as shown in Figures C and D or the equivalent. This fixture consists mainly of a spherical seated base that is center tapped to receive the extensometer extension corresponding to Figure G, or the equivalent. An appropriate thickness spacer plate is to be used under the specimen such that the spherical center of the ball seat will lie approximately on the surface of the specimen. This will eliminate any laterial movement of the specimen during alignment. A suitable dry film lubricant shall be used on the ball seat.

The compression test procedure shall be as follows:

1. Center the specimen on the spherical seated fixture base.

2. Bring the loading head of the machine down to contact the specimen and adjust the extensometer extension suspended from the spherical seat, so that it contacts the loading head through the center cell of the specimen.

3. Load the specimen to failure at a constant deflection rate of 0.0025 in/min., as monitored by a strain pacer. During the test a load versus deflection graph is to be recorded autographically using a gear magnification such that the curve will have an approximate 45° slope.

All calculations are to be performed as follows:

P = load at any time during test (lbs)

P_u = ultimate load at failure (lbs)

Δ = compressive deflection of the specimen (in)

P/Δ = initial straight line slope of the load versus deflection curve (lb/in)

t_c = core thickness (in)

A = apparent cross sectional area of the loading surface of the core specimen (in^2)

E_c = core compressive modulus of elasticity (PSI)

Bare Flatwise Compressive Cont.

$F_c = (P/\Delta)\ (t_c/A)$

F_{cu} = Ultimate core compressive strength (PSI)

$F_{cu} = Pu/A$

B. Flexural Shear Test Procedure:

The core ultimate shear strength and modulus of rigidity both transverse (W) and longitudinal (L) to the core ribbon direction are to be determined by a simple beam flexural test on 8 inch by 3 inch sandwich specimens.

The flexural shear test fixtures shall be as shown in Figures E and F, or the equivalent. The base of the test fixtures shall be tapped to receive the extensometer extension

The flexural shear test procedure shall be as follows:

1. Position the specimen on a six (6) inch span test fixture so that there is a one inch overhang beyond each support point. The bearing plates are to be as follows:

CORE TYPE AND RIBBON DIRECTION REF.	BEARING PLATE SIZE (B) RT AND 260°F	
	END SUPPORT PLATES	CENTER LOAD PLATE
I "L"	0.50	0.75
I "W"	0.25	0.50
II "L"	0.50	1.00
II "W"	0.25	0.50
III "L"	0.25	0.50
III "W"	0.50	1.00
IV "L"	0.50	1.00
IV "W"	0.50	0.75
V "L"	0.50	0.75
V "W"	0.25	0.50

Bearing Size Plates Table Cont.

VI "L"	0.25	0.50
VI "W"	0.50	0.75
VII "L"	0.50	0.75
VII "W"	0.25	0.50
VIII "L"	0.75	1.50
VIII "W"	0.75	1.50

2. Bring the loading head of the machine down to contact the specimens at the center of the span and adjust the extensometer extension, suspended from the test fixture base, so that it can contact the under side of the specimen directly below the center load point.

3. Load the specimen to failure at a constant deflection rate of 0.030 in/min as monitored by a strain pacer. During the test a load versus deflection graph is to be recorded autographically using a gear magnification such that the curve will have an approximate 45° slope.

4. At the point of failure immediately release the load and inspect according to Figure A for type of failure. Record the type of failure.

   Any specimen failing initially in the bond will not be acceptable for qualification testing and will be cause for retest of any of that group of specimens. For acceptance testing a bond failure is acceptable if the calculated results meet the requirements of Table II. If the results do not meet the requirements of Table II a retest will the required.

5. For a "G_c" determination to be reliably accurate it is necessary that the faces be of such a thickness that the results adhere to the following limits:

$$0.4 \leq \frac{P}{\Delta} \cdot \frac{L^3}{48D} \leq 0.6$$

   If the results do not adhere to these limits, the correct face thicknesses must be determined experimentally.

Flexural Shear Test Procedure Cont.

All caluclations are to be performed as follows:

P = load at any time during test (lbs)

P_u = ultimate load, at failure (lbs)

Δ = center span deflection (in)

L = span length

P/Δ = initial straight line slope of the load versus deflection curve (lb/in)

t = sandwich specimen thickness (in)

t_f = face thickness (in)

t_c = core thickness (in)

b = width of the sandwich specimen (in)

d = distance between the centroids of the sandwich specimen faces (in)

$d = \frac{t + t_c}{2}$

E_f = modulus of Elasticity of the face material (psi)

A_c = effective cross-sectional area of the sandwich specimen (in^2)

$A_c = bd$

G_c = core shear modulus of rigidity (PSI)

$$G_c = P/\Delta \; \frac{L t_c}{2tb(t+t_c)\left[1-(P/\Delta)\left(L^3/48D\right)\right]}$$

μ = Poisson's ratio of the face material

$$D = \frac{E_f b t_f (t+t_c)^2}{8(1-\mu^2)}$$

F_{s_u} = ultimate core shear strength (PSI)

$$F_{s_u} = \frac{P_u}{2A_c} = \frac{P_u}{2bc} = \frac{P_u}{b(t+t_c)}$$

Flexural Shear Test Procedure Cont.

ALUMINUM FACES	μ	E_f @ R.T.	E_f @ 260°F
Clad 7075-T6	0.33	10.4×10^6 psi	9.2×10^6 psi
Clad 2024-T86	0.34	10.6×10^6 psi	9.5×10^6 psi

Section IV Specification Requirement Mechanical Properties

PROPERTIES OF CORE MATERIALS
(MINIMUM REQUIREMENTS)

TYPE	DENSITY (lb/cu. ft.)		ULTIMATE FLATWISE COMPRESSIVE (PSI)		FLATWISE COMPRESSIVE MODULUS (KSI)	
	Test Para. 3.7.1		Test Para. 3.8.1		Test Para. 3.8.1	
	Log	Slice	Room Temp.	260°F*	Room Temp.	260°F*
I	8.5-9.5	8.0-9.5	1450	1375	103.0	80.0
II	4.5-5.1	4.4-5.2	535	420	36.0	28.0
III	8.5-9.5	8.0-9.8	900	825	70.0	55.0
IV	5.0-6.0	5.0-6.25	700	600	52.0	39.0
V	6.5-7.5	6.25-8.0	1000	950	78.0	59.0
VI	6.5-7.5	6.25-8.0	625	525	60.0	45.0
VII	9.5-10.5	9.5-11.0	1750	1575	111.0	88.0
VIII	4.0-5.0	4.0-5.0	260	160	32.0	22.0
IX	2.6-3.6	2.6-3.6	190	169	19.0	15.5

* Tested after 1/2 hr soak at 260°F

Specification Requirement Cont.

PROPERTIES OF SANDWICH CONSTRUCTION
(MINIMUM REQUIREMENTS)

TYPE			I	II	III	IV	V	VI	VII	VIII
Shear Strength (PSI)	L	R.T.	540	310	300	360	450	225	580	140
		260°F*	460	285	245	320	400	190	495	110
	W	R.T.	350	190	445	210	280	330	410	150
		260°F*	270	165	375	180	215	280	330	120
Shear Modulus (KSI)	L	R.T.	31.0	16.5	12.0	19.0	24.0	9.0	36.0	6.0
		260°F*	22.0	9.0	10.0	10.5	13.5	7.5	25.0	4.5
	W	R.T.	19.0	11.0	34.0	13.0	16.5	23.0	21.5	10.0
		260°F*	13.0	7.0	31.0	8.0	10.5	20.0	15.0	6.0

* Tested at 260°F after 1/2 hour exposure at 260°F.

NOTES: (1) "L" denotes a beam tested with the ribbon direction parallel to the length (longitudinal).

(2) "W" denotes a beam tested with the ribbon direction parallel to the width (transverse).

Section V Additional Qualification Honeycomb Products Co.

TYPE OF CORE	COMPRESSION		COMPRESSION MOD.	
	RT PSI	260°F PSI	RT KSI	260°F KSI
I	2652	2000	144.2	114.5
II	854	673	52.2	40.0
III	1114	949	82.5	64.4
IV	1091	970	83.5	70.7
V	2000	1652	115.2	103.0
VI	1409	1211	81.8	65.1
VII	1820	1670	113.1	90.2
VIII				
IX				

TYPE OF CORE	"L" SHEAR STRENGTH		"W" SHEAR STRENGTH	
	RT PSI	260°F PSI	RT PSI	260°F PSI
I	571	505	373	321
II	374	349	246	198
III	310	269	549	490
IV	410	385	238	233
V	533	455	316	251
VI	321	271	441	418
VII	627	540	460	390
VIII				
IX				

TYPE OF CORE	"L" SHEAR MOD		"W" SHEAR MOD	
	RT KSI	260°F KSI	RT KSI	260°F KSI
I	43.8	35.5		
II	25.2	19.8		
III	15.2	13.		
IV	22.1	15.3	14.2	
V	32.8	28.7		
VI	12.9	10.4		
VII	51.1	36.6		
VIII				
IX				

Section V Cont. Hexcel Products

TYPE OF CORE	COMPRESSION		COMPRESSION MOD	
	RT PSI	260°F PSI	RT PSI	260°F KSI
I	1611	1485		
II	786	598	51.8	47.8
III	1847	1351	108.8	73.0
IV	830	741		
V	1282	1235		
VI	1398	1176	84.2	69.0
VII	1827	1711		
VIII	329		55.3	
IX	238	212	21.	19.

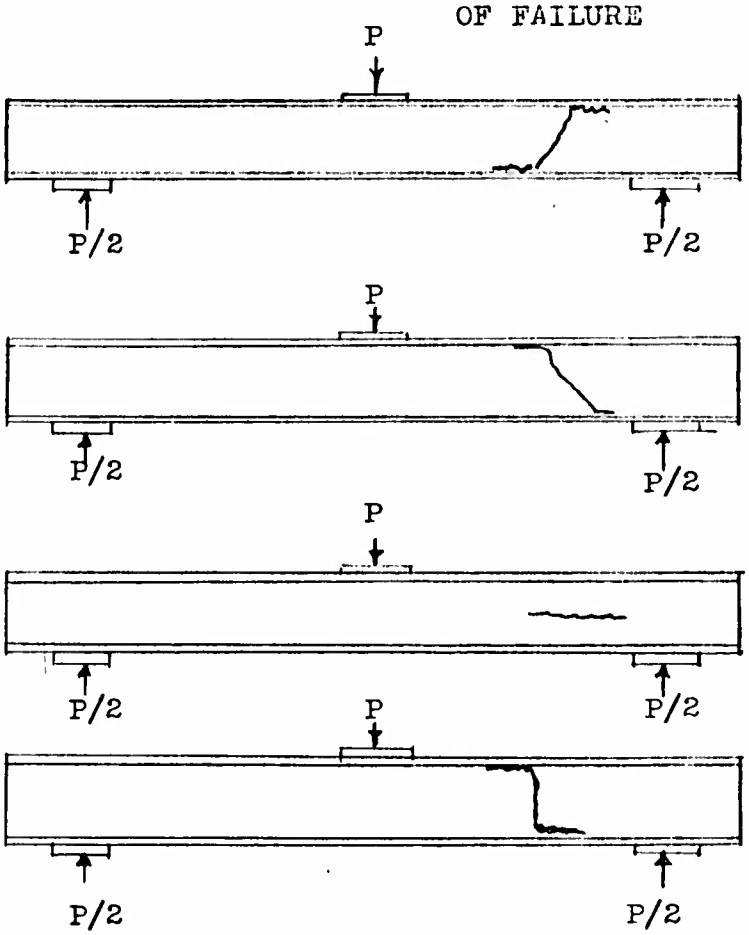
TYPE OF CORE	"L" SHEAR STRENGTH		"W" SHEAR STRENGTH	
	RT PSI	260°F PSI	RT PSI	260°F PSI
I	653	587	487	423
II	442	375	246	212
III	383	335	631	518
IV	473	409	250	221
V	643	506	411	305
VI	346	307	529	460
VII	762	679	534	440
VIII	183		193	
IX	131	110	163	152

TYPE OF CORE	"L" SHEAR MOD		"W" SHEAR MOD	
	RT KSI	260°F KSI	RT KSI	260°F KSI
I	34.5	29.7	22.5	17.7
II	31.5	25.5	16.2	13.2
III	24.4	14.1	61.6	47.8
IV	25.9	22.5	12.6	10.2
V	30.4	22.0	18.6	15.2
VI	18.9	15.0	47.6	35.5
VII	42.6	29.4	24.2	18.7
VIII	4.0		13.4	
IX	5.8	4.8	14.8	10.7

FIGURE A

FLEXURAL SHEAR TEST TYPES

OF FAILURE



Class 1 Failure

Diagonal compression failure possible accompanied secondarily by a bond failure.(Acceptable).

Class 2 Failure

Diagonal tension failure possibly accompanied secondarily by a bond failure. (Acceptable).

Class 3 Failure

Horizontal jagged edge shear failure. (Acceptable)

Class 4 Failure

Initial bond failure possibly accompanied secondarily by a vertical shear failure. (Not acceptable).

FIGURE C

2-19399 8-7-59
FLATWISE COMPRESSION -
TEST JIG- B-58 F-[illegible]911
CONVAIR FT. WORTH TEXAS

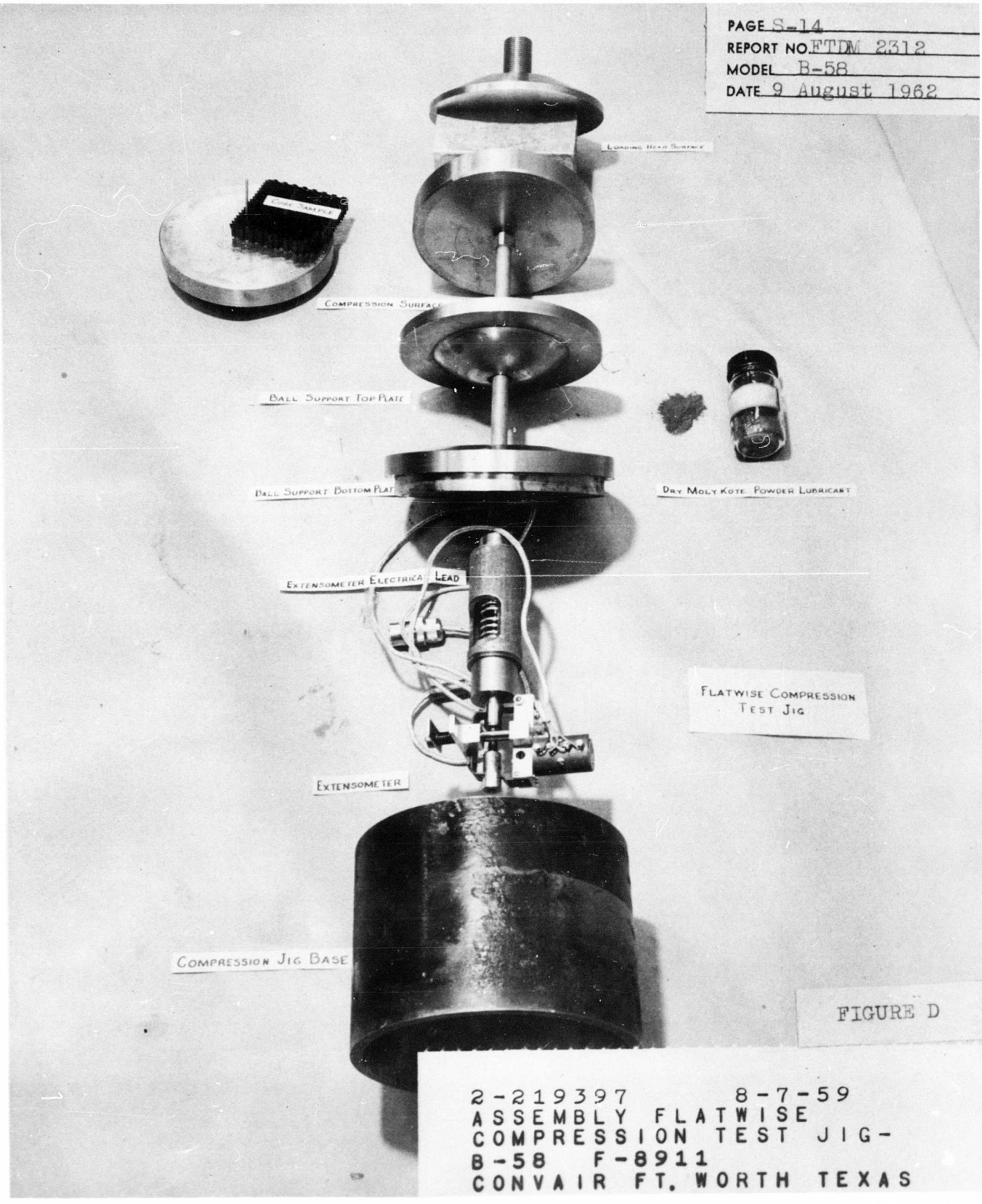


FIGURE D

2-219397 8-7-59
ASSEMBLY FLATWISE
COMPRESSION TEST JIG-
B-58 F-8911
CONVAIR FT. WORTH TEXAS

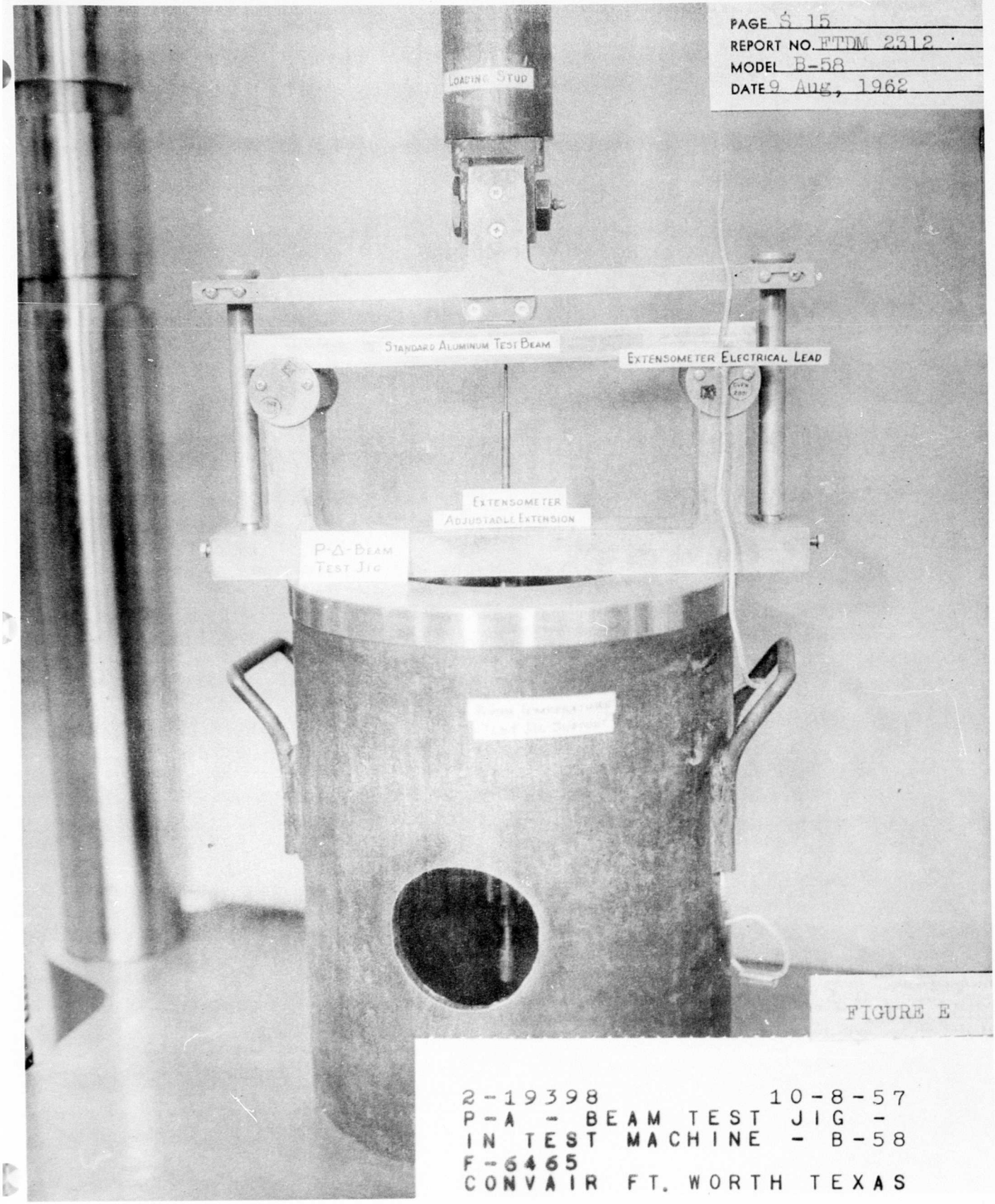


FIGURE E

2-19398 10-8-57
P-A - BEAM TEST JIG -
IN TEST MACHINE - B-58
F-6465
CONVAIR FT. WORTH TEXAS

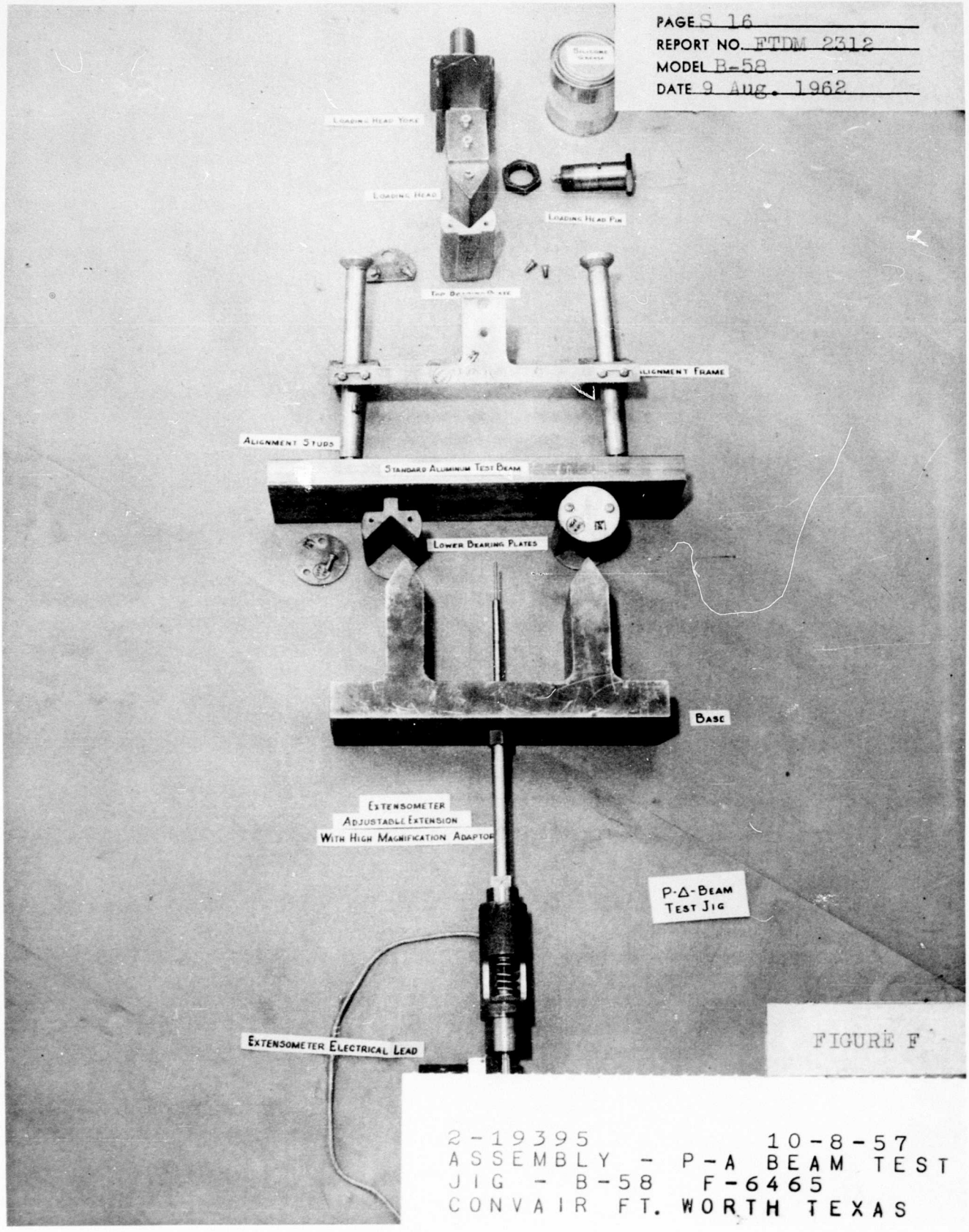


FIGURE F

2-19395 10-8-57
ASSEMBLY - P-A BEAM TEST
JIG - B-58 F-6465
CONVAIR FT. WORTH TEXAS

UNCLASSIFIED